A Fiber-Coupled Plasmonic Spectrometer for In Situ Characterization of Solar System Surfaces

Completed Technology Project (2016 - 2019)

Project Introduction

We propose the development of a plasmonic spectrometer for the in situ characterization of solar system surfaces and subsurface environments. This instrument system has a range of applications for which knowledge of a planetary or small body surface reflectance is desired. Using an asteroid as an example target, the proposed plasmonic spectrometer can be used to distinguish between various asteroid types (ordinary chondrites, carbonaceous chondrites, metallic, and basaltic) using optical and near-infrared (NIR) reflectance spectra. A study of the surface mineralogy and the search for volatiles on solid bodies such as asteroids, Mars, or satellites can provide insight into origins and the distribution of volatiles throughout the solar system. The spectrometer will be coupled to a probe via optical fibers, and thus can be used for surface measurements as well as the study of compositional variations with depth. This miniaturized, chip-scale spectrometer is aligned with the trend of small size, low mass, and low power instruments being developed for future planetary spacecraft. The proposed instrument development program will consist of a multifaceted approach where we explore illumination and light gathering strategies for on- or near-surface studies of solar system bodies using optical fibers. The gathered light will then be sent to a plasmonic spectrometer designed using the principles of extraordinary optical transmission. This design enables the transmission of light through subwavelength apertures that have been patterned in a metallic film with a regularly repeating periodic structure. The interaction of light with the metal surface results in excitation of electrons and the formation of a surface plasmon. The regularly spaced structure on the surface enables much higher transmission efficiency as a result of constructive interference due to the presence of surface plasmon resonances. An array of these apertures will be used for wavelength discrimination and the acquisition of a spectrum. We will explore both the optical and near-infrared spectral regions in order to fully characterize a planetary surface spectrum. This proposal is directly responsive to the Planetary Instrument Concepts for the Advancement of Solar System Observations solicitation, which is focused on innovative, early-stage instrument systems that will improve measurement capabilities for planetary science missions designed to address NASA's Planetary Science Division goals and objectives. Our proposed instrument will focus on the characterization of planetary surfaces and subsurface environments. The identification of volatiles, ices, carbonaceous compounds, and metals will be paramount for advancing our understanding of these bodies and laying the foundations for future planetary exploration. Our proposed technology development will make use of a cutting-edge nanophotonics technique that has broad applications for future NASA missions. This technology will begin at a Technology Readiness Level (TRL) of 2 and we will achieve a TRL of 3 by the end of the proposed award period. Our team contains expertise in the areas of planetary science, instrument development for planetary science applications, eletro-optics and nanophotonics, and mission architectures for planetary exploration, hence we are ideally suited for the proposed tasks.

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Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Planetary Instrument Concepts for the Advancement of Solar System Observations

A Fiber-Coupled Plasmonic Spectrometer for In Situ Characterization of Solar System Surfaces

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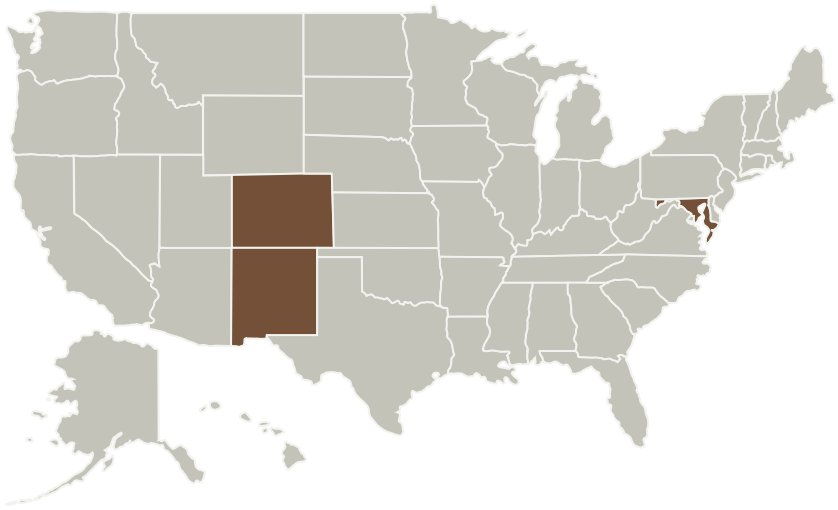
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
New Mexico State University-Main Campus	Supporting Organization	Academia Alaska Native and Native Hawaiian Serving Institutions (ANNH), Hispanic Serving Institutions (HSI)	Las Cruces, New Mexico

Primary U.S. Work Locations	
Colorado	Maryland
New Mexico	

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Haris Riris

Principal Investigator:

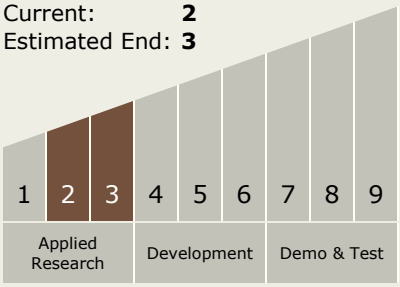
Nancy J Chanover

Co-Investigators:

Sang-yeon Cho
Alisha Giron
Dennis Reuter
Daniel L Scheld
David Voelz
Amy A Simon

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors

Continued on following page.

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Technology Areas *(cont.)*

- TX08.3.4 Environment Sensors

Target Destination

Others Inside the Solar System